Research Article / Araştırma Makalesi

EXPLORATION OF CAUDATE NUCLEUS DEGENERATION FOLLOWING SUBARACHNOID HEMORRHAGE: AN EXPERIMENTAL STUDY

SUBARAKNOİD KANAMA SONRASI KAUDAT ÇEKİRDEK DEJENERASYONUNUN ARAŞTIRILMASI: DENEYSEL BİR ÇALIŞMA

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Abstract

Objective: Although the caudate nucleus is the closest neighbor of the lateral ventricles, it can lead to the unknown cause of many psychomotor disorders that develop after subarachnoid hemorrhages. This subject has not been adequately studied yet. The study aims to examine the histopathological changes in the caudate nucleus after subarachnoid hemorrhage. **Material and Methods:** Twenty-five wild male healthy rabbits were used. Their weights, heart and respiration rates, and blood pressure values were recorded. Animals were divided into the control (GI, n=5); SHAM (1.2 ccs of saline injected (GII, n=5), and study group (GIII, n=15). In the study group, 1.2 ccs of autologous blood was injected into the cisterna magna of animals. The animals were followed up for three weeks and sacrificed under general anesthesia. Degenerated neuron densities of the caudate nucleus were estimated by the stereological methods and analyzed by the Mann-Whitney U test. **Results:** Three rabbits were dead in the study group. Meningeal irritation signs and unconsciousness were noted in those animals. Prolonged QT intervals, ST depressions, and low voltage QRSs were observed in GIII animals. Numerical values of mean heart-respiratory rates (n/min), degenerated neuron densities of the caudate nucleus (n/mm3) as follows: 226±30/22±5/9±3 in GI; 211±18/16±4/13±4 in GII; and 188±19/14±4/98±13 GIII. P values: p<0.005 in GI/GII; p<0.0005 in GII/GIII and p<0.00001 in GI/GIII. **Conclusion:** Subarachnoid hemorrhage causes spasms of the arteries supplying the caudate nucleus, leading to ischemic injury.

Keywords: Subarachnoid hemorrhage, Caudate nucleus, psychomotor disorders

Özet

Amaç: Giriş: Kaudat çekirdek lateral ventriküllerin en yakın komşusu olmasına rağmen subaraknoid kanamalar sonrası gelişen pek çok psikomotor bozukluğun nedeni bilinmeyene yol açabilmektedir. Bu konu henüz yeterince çalışılmamıştır. Bu çalışma, subaraknoid kanama sonrası kaudat çekirdekte meydana gelen histopatolojik değişiklikleri incelemeyi amaçlamaktadır. **Materyal ve Metod:** 25 adet yabani erkek sağlıklı tavşan kullanıldı. Ağırlıkları, kalp ve solunum hızları, tansiyon değerleri kaydedildi. Hayvanlar kontrol grubuna ayrıldı (GI, n=5); SHAM (1,2 cc salin enjekte edildi (GII, n=5) ve çalışma grubuna (GIII, n=15) Çalışma grubunda hayvanların sisterna magnalarına 1,2 cc otolog kan enjekte edildi. Hayvanlar takibe alındı. kaudat çekirdeğin dejenere nöron yoğunlukları stereolojik yöntemlerle tahmin edildi ve Mann-Witney U testi ile analiz edildi. **Bulgular:** Bir çalışma grubunda üç tavşan öldü. Bu hayvanlarda meningeal tahriş belirtileri ve bilinç kaybı kaydedildi. GIII hayvanlarında uzamış QT aralıkları, ST çöküntüleri ve düşük voltajlı QRS'ler gözlendi. Ortalama kalp-solunum hızlarının (n/dak), kaudat çekirdeğin dejenere nöron yoğunluklarının (n/mm3) sayısal değerleri aşağıdaki gibidir: GI'de 226±30/22±5/9±3; GII'de 211±18/16±4/13±4; ve 188±19/14±4/98±13 GIII. P değerleri: GI/GII'de p<0,005; GII/GIII'de p<0,0005 ve GI/GIII'de p<0,00001. **Sonuç:** Subaraknoid kanama kaudat çekirdeği besleyen arterlerde spazmlara neden olarak iskemik yaralanmaya neden olur.

Anahtar Kelimeler: Subaraknoid kanama, kaudat nucleus, psikomotor bozukluklar

1. INTRODUCTION

The caudate nucleus is covered by the frontal horn floor of the lateral ventricle, the knee of the corpus callosum, the thalamus, the lenticular nucleus, and the internal capsule. Caudate nucleus injuries are often presented with behavioral abnormalities, and motor and ability disorders (1). The caudate nucleus is supplied by the middle and anterior cerebral arteries (2). Spasms of these arteries can cause caudate degeneration (3) and amyloid angiopathy (4). Hydrocephalus might affect the caudate nucleus (5) after subarachnoid hemorrhage (6). In the general population, cerebral aneurysms occur 5 to 6% of the time (7, 8). Subarachnoid hemorrhage (SAH), which is caused by these ruptures, accounts for roughly 5-10% of strokes (9). The caudate nucleus hemorrhages can result from hypertension (10) and caudate

hemorrhages frequently cause intraventricular hemorrhages (11). There are major changes in neuroscience practice (12). With its unpredictable behavior (13) and grim prognosis, SAH is a devastating disease. It continues to explain high death rates (14). Its outcome still needs to be improved (9), but no studies have been done on the changes that SAH causes in the caudate nucleus. The study aims to examine the histopathological changes in the caudate nucleus after subarachnoid hemorrhage.

2. MATERIAL AND METHOD

Twenty-five, wild rabbits were used in this study. Weights, heart-respiration rates, and blood pressure values of animals were recorded. All animals were randomly divided into three groups: control (GI, n=5); SHAM in whom 0.75 ccs of saline was given (n=5) and study (GIII, n=16) in whom an autologous 0.75 cc blood was injected into their cisterna magna. Ethical approval for this study was obtained from our institutional ethical committee (B.30.2.ATA.0.23.85-41) by the National Institutes of Health Guide for the Care and Use of Laboratory Animals (NIH Publications No. 8023, revised 1978). The animals were sacrificed after general anesthesia with isoflurane by a face mask, 0.2 mL/kg; Ketamine HCL, 150 mg/1.5 mL; Xylazine HCL, 30 mg/1.5 mL; and distilled water, 1 mL. Brains were removed just after intracardiac formalin injection and then fixed in 10% of formalin solution for one week. Microsections of the caudate nucleus were done parallel with an axial plane to observe neuronal numbers and stained with hematoxylin-eosin and GFAP. Twenty sections (5µm) of the caudate nucleus were examined to estimate degenerated neurons by the stereological methods which were described in our previous reports (15). All values are expressed as the mean±SD. The differences between the degenerated neuron densities of the caudate nucleus in each group were compared statistically. A one-way analysis of variance (ANOVA) followed by Bonferroni's Post Hoc Test was used to determine significant differences between the groups. Differences were considered to be significant at $p< 0.05$.

3. RESULTS

3.1. Clinical Results

Three rabbits of the study group were dead in the first week and three animals were added to the study group. Prolonged Q-T intervals, ST-segment depressions, and low voltage QRSs were noticed in the study group animals compared to slightly normal animals. Clinical and post-mortem findings of cerebral edema were more severe in study group animals than other two groups. Numerical documents of heart-respiratory rates (n/min) as follows: 226±30/22±5 in GI; 211±18/16±4 in GII; and 188±19/14±4 in GIII.

3.2. Histopathological Results

Histologically, cellular angulation, nuclear shrinkage, cytoplasmic condensation, and cellular darkening were accepted as criteria for neuronal degeneration as in the study by Yilmaz et al. (16). Figure-1: Lateral ventricles, caudate nuclei (CN) in an animal of the control group. Figure 2: In an animal of the control group. (A) lateral ventricles, caudate nuclei (CN) (A); Normal caudate nucleus neurons and glial cells are observed in the control group (B). Slightly degenerated neurons and glial cells with broken branches are observed in the SHAM group (C). In the study group, highly degenerated neurons and broken glial cells with severely lost branches are observed.

3.3 Numerical Results

Three dead rabbits in the study group were represented by meningeal irritation signs and unconsciousness. Numerical documents about degenerated neuron densities of the caudate nucleus (n/mm3) are as follows: 9±3 in GI; 13±4 in GII; and 98±13 GIII.

3.4. Statistical Results

P values: $p<0.005$ in GI/GII; $p<0.0005$ in GII/GIII and $p<0.00001$ in GI/GIII.

4. DISCUSSION

The caudate nucleus is an underpass between the basal ganglia and the cerebral cortex, gearing the ongoing modulation of psychomotor behavior between consciousness and unconsciousness. Its head, body, and tail are its three main sections. The telencephalic cortex is stroked by the head of the caudate nucleus, which extends behind the anterior section of the thalamus and forms the floor of the lateral ventricle along with the frontal horn. The knee of the corpus callosum covers the upper part of the head, and the thalamus, lenticular nucleus, and internal capsule make up the lower section of the head. Caudate nucleus strokes are often presented with behavioral abnormalities, dysarthria, movement disorders, language disturbances, and memory loss (1). Behavioral abnormalities are frequently seen in patients with a caudate lesion (17). The caudate nucleus is supplied by the middle cerebral artery and anterior cerebral arteries (2). Spasms of the Heubner's artery can lead to caudate nucleus degeneration (3). Subarachnoid hemorrhage-related ischemic injuries are frequently seen due to vasospasm of caudate nucleus arteries (18). Anterior choroidal artery ruptures are

Figure 1: Lateral ventricles, caudate nuclei (CN) in an animal of the control group(A); Mildly dilated lateral ventricles (B) in the SHAM group and ischemic pathology in dilated ventricles and caudate nucleus units in addition to degenerated choroid plexuses in the study group (LM, H&E, x4).

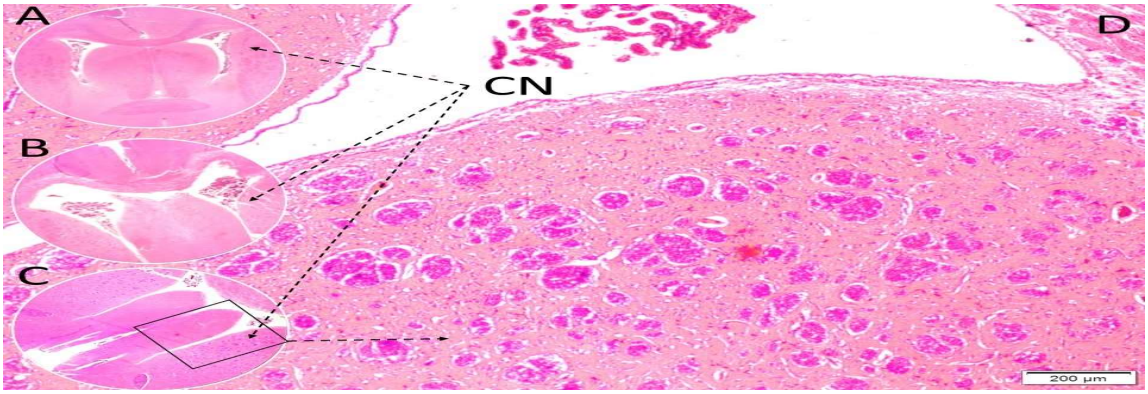
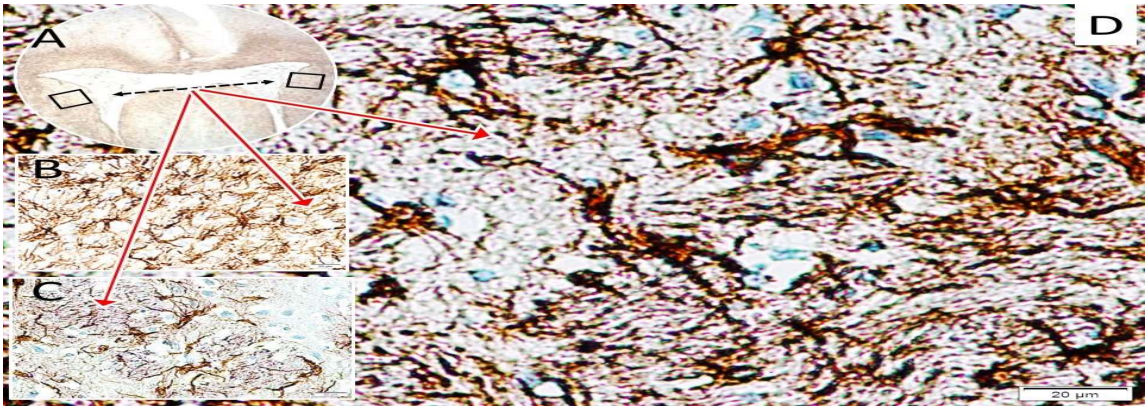


Figure 2: In a normal subject (A) lateral ventricle, caudate nuclei (CN) (A); Normal caudate nucleus neurons, and glial cells are observed in the control group (B). Slightly degenerated neurons and glial cells with broken branches are observed in the SHAM group (C). In the study group, highly degenerated neurons and broken glial cells with severely lost branches are observed (LM, GFAP, x4/A; x40/B-D).



one of the causes of caudate nucleus hemorrhages, and anterior choroidal artery vasospasm occurs in experimental SAH (16). Caudate nucleus hemorrhages can occur in SAH. When it is understood that the caudate nucleus is the most important modulator of the neural network, which is the brain's software and intelligence, a new era may begin for the basal ganglia. In this study, that ischemic injury of the caudate nucleus was observed secondary affection of SAH-induced spasm of the arteries supplying the caudate nucleus. Figures 1 and 2 show changes in the caudate nucleus in all three groups of animals. Highly degenerated neurons and broken glial cells of the caudate nucleus can be seen in Figure 2.

Limitations: This study does not include clinical data.

5. CONCLUSION:

This study indicates that subarachnoid hemorrhage might lead to spasms of the arteries supplying the caudate nucleus, leading to ischemic injury. As a result, caudate nucleus degeneration following SAH can be the source of psychological, psychiatric, and mental disability, speech and comprehension disorders, as well as severe mental destructions that will soon be enlightened. More studies are required.

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Conflict of interest: None

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